PATENT SPECIFICATION (11) 1 424 986

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(21) Application No. 21583/74 (22) Filed 15 May 1974
(31) Convention Application No. 440 990
(32) Filed 11 Feb. 1974 in
(33) United States of America (US)
(44) Complete Specification published 11 Feb. 1976
(51) INT CL² H01F 27/00
(52) Index at acceptance
H1T 1C 1F 7A4 7A5 7A7 7A9 7C2 7C5

(19)

(54) AN ELECTROMAGNETIC DEVICE

(71) I, RENE VILLASENOR DE RIVAS, of 2205 West Sixth Street, Los Angeles, California 90057, United States of America, a Citizen of the United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an electromagnetic device wherein the direction of magnetic flux from a permanent magnet and flowing in a core member is rapidly alternated to general an alternating current in a winding on the core member.

Permanent magnets have long been recognized and used as sources of magnetic flux both separately and in combination with electromagnets as means of concentrating magnetic flux. In such instances, as the frequency of the control signal to the electromagnet has increased, so has the coil reactance of the electromagnet and the effective reluctance of the magnetic flux path.

According to the present invention there is provided an electromagnetic device comprising: a permanent magnet having a north and a south pole; first and second magnetic flux circuits between the north and south pole external to the permanent magnet and each including first and second switching means for opening and closing the magnetic flux circuits; a core member composed of a high permeability magnetic material connected at opposite ends to the first and second magnetic flux circuits between the first and second switching means respectively; a winding of electrically conductive material on the core member for connection to an external load circuit; and means for alternately operating the first switching means and the second switching means of said first flux circuit respectively, and the second switching means and the first switching means of said second flux circuit respectively whereby the direction of magnetic flux in said core member from said permanent magnet is rapidly alternated to generate an alternating current in the winding for application to the load circuit.

The invention will now be described in more detail, by way of example only with reference to the accompanying drawings, in which:—

FIGURE 1 is a perspective view of an electromagnetic device constructed in accordance with the present invention;

FIGURE 2 is a sectional side view of the electromagnetic device taken along the line 2—2 of Figure 1;

FIGURE 3 is a front view of the electromagnetic device of Figure 1, including a diagrammatic representation of the circuitry for applying a high-frequency, low magnitude control signal to the electromagnetic device to rapidly alternate the direction of magnetic flux flow from a permanent magnet in a core member to produce a relatively high magnitude alternating current in windings on the core member;

Figs. 4(a) and 4(b) are front and side views respectively of the electromagnetic device diagrammatically representing the condition of the device during a first half-cycle of the control signal to cause magnetic flux from the permanent magnet to flow in a first direction through a core member; and

Figs. 5(a) and 5(b) are front and side views similar to Figs. 4(a) and 4(b) diagrammatically representing the condition of the electromagnetic device during a second half cycle of the control signal to cause magnetic flux from a permanent magnet to flow in an opposite direction in the core member.

The electromagnetic device comprises a strong permanent magnet 10 having a north pole 12 and a south pole 14. Connecting the north and south poles of the permanent magnet are two magnetic flux circuit means or paths 16 and 18. The magnetic flux path 16 includes first and second switching means 20 and 22 for opening and closing the magnetic flux path 16 while the magnetic flux path 18 includes first and second switching means 24 and 26 for functioning in

a similar manner relative to the second magnetic flux path. Intersecting the flux paths 16 and 18 and connected thereto between the first and second switching means 20 and 22 and 24 and 26, respectively, is a core member 28 of high permeability material carrying windings 30 and 32 of electrically conductive material for connecting to an external load circuit.

Normally, magnetic flux from the north pole 12 of the permanent magnet 10 will divide and flow simultaneously through the magnetic flux paths 16 and 18 to the south pole 14. In operation of the present invention, however, electric circuit means 34 functions to alternately operate the switching means 20 and 26 and the switching means 22 and 24 to selectively open and close segments of the flux paths 16 and 18 such that the direction of magnetic flux from the permanent magnet 10 is alternated in flowing in the core member 28 to generate an alternating current in the windings 30 and 32 for application to an external load circuit.

Preferably, the switching means are capable of operating in response to a low magnitude, high frequency control signal to produce a high frequency alternation in the direction of flux flow in the core member to generate a relatively high magnitude alternating current: the magnitude of the alternating current being a function of the rate of change of the direction of flux flow in the core member.

More particularly, in the illustrated form of the present invention, the permanent magnet 10 is a bar magnet while the two magnetic flux paths 16 and 18 comprise a member of high permeability material formed as a closed loop external to and between the north and south poles 12 and 14. While such a member is illustrated in Fig. 1 as being a single piece member, it is appreciated that the member may be segmented as desired.

In the present invention, various forms of switching means may be employed. Of course, for a very low frequency device, segments of the high permeability member comprising the flux paths 16 and 18 may for the switching means in combination with means for mechanically or manually moving the segments from the member to open the flux paths on a selective basis.

Preferably, for high frequency operations, the switching means each include means for crosss-saturating a region of the high permeability member substantially normal to the direction of flux flow from the magnet 10. Such saturation immediately increases the reluctance of the flux path to effectively open the associated magnetic flux path in the region of the switching means.

One torm of such a cross-saturating mechanism is illustrated in the drawing for each switching means and comprises a horseshoe-shaped magnetic core with ends on opposite sides of the high permeability member and carrying a low inductance coil. For the switching means 20, 22, 24 and 26 such horseshoe-shaped cores are represented by the numerals 36, 38, 40 and 42 and their associated low inductance coils by the numerals 44, 46, 48 and 50, respectively. The structure and operation of each such switching means is the same. For example, to operate the switching means 20, current is applied to the coil 44. This generates a magnetic flux in the core member 36 flowing perpendicular to the high permeability member comprising the flux path 16 to saturate the region between the ends of the core members 36 substantially normal to the direction of flux flow from the magnet 10. This effectively opens the flux circuit means 16 to block the flux flow from the magnet through the switching means 20. When current ceases flowing in the coil 44, the magnetic flux flowing in the core 36 terminates to again return the switching means 20 and the flux path 16 to an effective closed circuit condition.

As previously indicated, the selective and alternating operation of the switching means 20, 22, 24 and 26 in accordance with the present invention causes the direction of flux flow in the core member 28 to be rapidly alternated thereby inducing an alternating current in the windings 30 and 32. In this regard, and as illustrated most clearly in Fig. 2, the core member 28 preferably comprises a pair of generally U-shaped elements 52 and 54 of high permeability material carrying the windings 30 and 32 respectively, and having corresponding ends 56, 58 and 60, 62 bearing on opposite sides of the member comprising the flux paths 16 and 18 between the switching means 20 and 22, and between the switching means 24 and 26. Because of the high permeability of the elements 52 and 54 and the location of their end faces against the member comprising the flux paths 16 and 18, as the switching means are selectively and alternately operated, the core member 28 becomes a relatively low reluctance path for flux from the permanent magnet 10 between the north and south poles thereof.

The circuit means 34 for controlling the switching means and hence the direction of magnetic flux flow in the core member 28 is diagrammatically represented in Fig. 3 and comprises a source 64 of a high frequency alternating current control signal having its output connected in common to four parallel circuits connected to the coils 44, 46, 48 and 50 of the switching means 20, 22,

24 and 26, respectively. Each parallel circuit includes a diode or other unidirectional current conductive device illustrated at 66, 68, 70 and 72 for the parallel circuits associated with the switching means 20, 22, 24 and 26, respectively. The diodes 66 and 68 associated with the switching means 20 and 22 are poled in opposite directions as are the diodes 70 and 72 associated with the switching means 24 and 26. The diodes 66 and 72 and the diodes 68 and 70 being poled in like directions.

Thus during a first or positive going half cycle of the control signal from the source 64, current flows through diodes 66 and 72 and the coils 44 and 60 while current is blocked by the diodes 68 and 70 from the coils 46 and 48. The current flowing in the coils 44 and 50 induces a magnetic flux in the associated core members 36 and 42 to saturate regions of the high permeability member comprising the flux paths 16 and 18 and effectively blocks flux flow from the magnet beyond the switching means 20 and 26 — there being a high reluctance in the region of the switching means and flux from the permanent magnet 10 following the path of lowest reluctance from the north pole 12 of the magnet through the flux path 18 and switching means 24 to a junction with the core member 28. Such a condition for the electromagnetic device of the present invention is diagrammatically depicted in Figs. 4(a) and 4(b), the cross at switching means 20 and 26 representing that they are in an effectively open condition.

As depicted in Fig. 4(b) at the junction of the path 18 and core member 28, the flux divides flowing upwardly in the elements 52 and 54 and joining at the junction of the core member 28 and the flux path 16 to flow through the flux path 16, the switching means 22, and to the south pole 14 of the magnet. Such flux flow in the core member 28 induces a current in a first direction in the windings 30 and 32.

During a second or negative going half cycle of the alternating control signal from the source 64, current only passes through the diodes 68 and 70 to flow through the coils 46 and 48. Such current flow produces a cross saturation of the high permeability member comprising the flux paths 16 and 18 in the regions of the switching means 22 and 24 to effectively open such portions of the flux paths. Under such conditions and as illustrated diagrammatically in Figs. 5(a) and 5(b), magnetic flux from the permanent magnet 10 following the path of lowest reluctance flows upwardly in the flux path 16 through the switching means 20 to a junction of the core member 28. There, the magnetic flux divides and flows downwardly through the elements 52 and 54 to join at a junction of the flux path 18. Flux then continues to flow in the flux path 18 to the south pole 14 of the magnet 10. Such flux flow in the elements 50 and 52 of the core member 38 induces a current in the windings 30 and 32 flowing in an opposite direction to that induced during the positive-going half cycle of the control signal from the source 64. Thus, during alternate half cycles of the control signal, relative negative and positive going signals are induced in the windings 30 and 32 to produce an alternating current for application to a load circuit connected to the windings.

WHAT I CLAIM IS:—

1. An electromagnetic device comprising:

a permanent magnet having a north and a south pole;

first and second magnetic flux circuits between the north and south pole external to the permanent magnet and each including first and second switching means for opening and closing the magnetic flux circuits;

a core member composed of a high permeability magnetic material connected at opposite ends to the first and second magnetic flux circuits between the first and second switching means respectively;

a winding of electrically conductive material on the core member for connection to an external load circuit; and

means for alternately operating the first switching means and the second switching means of said first flux circuit respectively, and the second switching means and the first switching means of said second flux circuit respectively whereby the direction of magnetic flux in said core member from said permanent magnet is rapidly alternated to generate an alternating current in the winding for application to the load circuit.

2. An electromagnetic device as claimed in claim 1 wherein the first and second magnetic flux circuits each includes a high permeability member between the north and south poles of the permanent magnet; and

the first and second switching means each includes means for saturating a region of the high permeability member substantially normal to the direction of flux flow in the member to block selectively flux flow from the magnet in the member and thereby open the flux circuit.

3. An electromagnetic device as claimed in claim 2 wherein each of the means for saturating a region of the high permeability member includes a horseshoe-shaped core with ends on opposite sides of the high permeability member and carrying a low inductance coil.

4. An electromagnetic device as claimed in claim 3 wherein the means for saturating

a region of said high permeability members includes:

a source of high frequency alternating current; and

circuit means for allowing only positive half-cycles of said high frequency alternating current to pass through said coils associated with said first switching means and second switching means of said first and second flux circuit means respectively, and only negative half-cycles to pass through said coils, associated with said second switching means and first switching means of said first and second flux circuit means respectively.

5. An electromagnetic device substantially as herein described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1976.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale

FIG. 1.

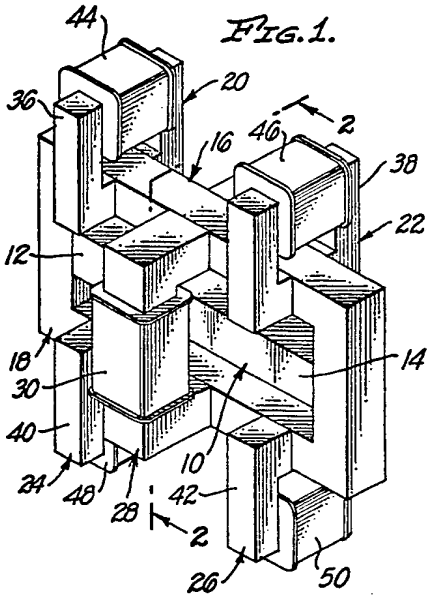

FIG. 4a.

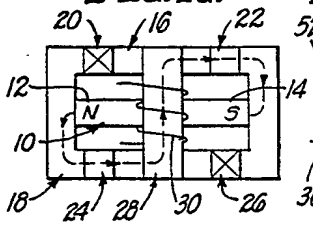

FIG. 4b.

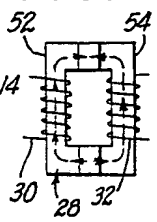

FIG. 5a.

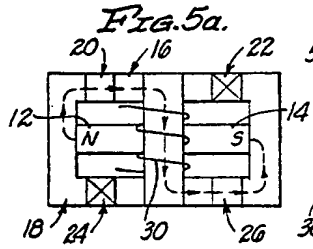

FIG. 5b.

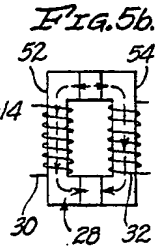

FIG. 2.

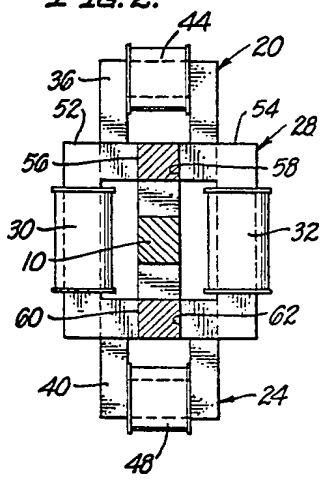

FIG. 3.